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MANPOWER NEEDS AT WATER POLLUTION CONTROL FACILITIES IN NEW ENGLAND

Paul Ferraro

Federal Water Pollution Control Administration
Needham Heights, Massachusetts

June 1969

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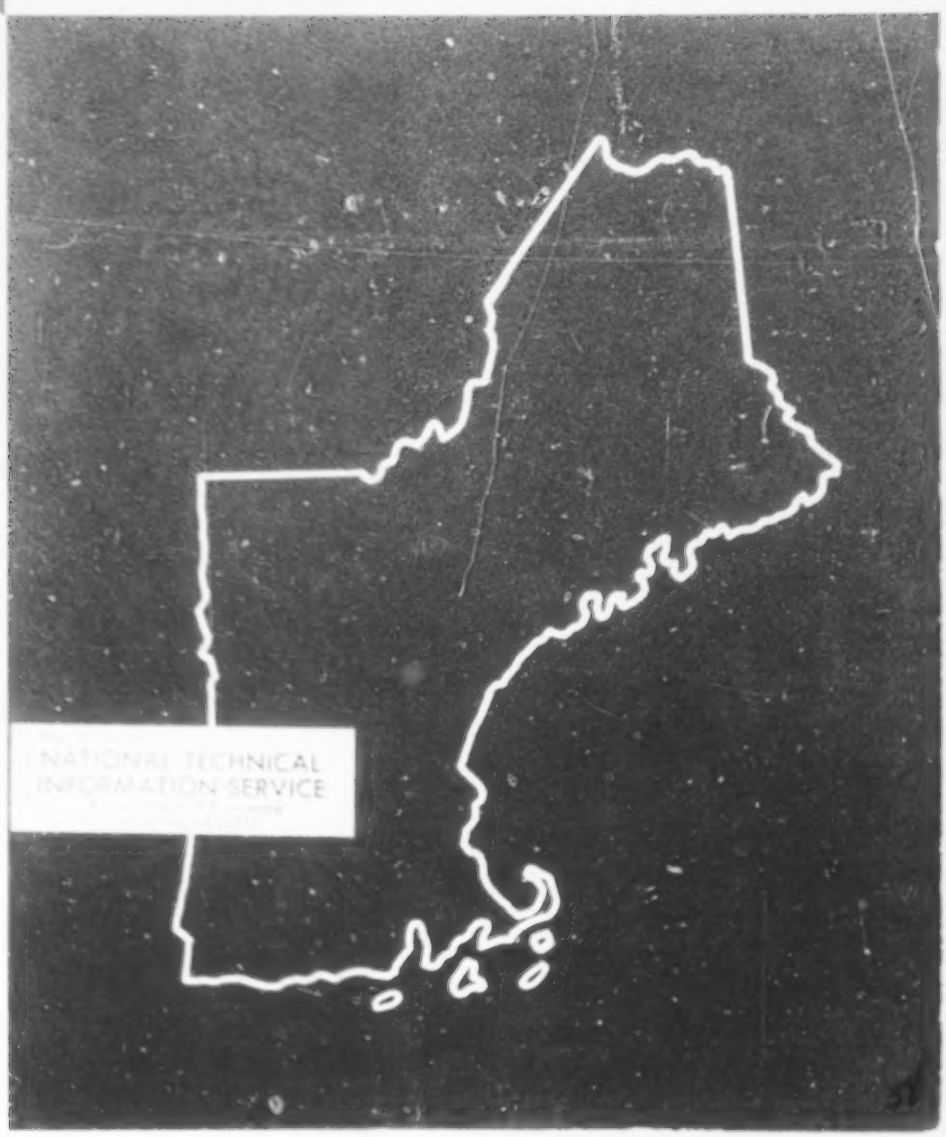
June 1969

FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

an evaluation of needs in the operation of waste treatment facilities: manpower salaries training certification recruitment



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MANPOWER NEEDS
AT
WATER POLLUTION CONTROL FACILITIES
IN
NEW ENGLAND

by

Paul Ferraro

United States Department of the Interior
Federal Water Pollution Control Administration
Northeast Region
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Needham Heights, Massachusetts

June 1969

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INTRODUCTION

Numerous operational and maintenance problems plague New England's wastewater treatment plants. The situation throughout the area may be compounded by rapidly expanding construction programs and by a lack of well trained plant operators. The effectiveness of the total water pollution control program is largely dependent on the proper and efficient operation of all treatment facilities. Effectiveness cannot be accomplished without the recruitment and retention of qualified personnel for existing and future facilities.

The Federal Water Pollution Control Administration has evaluated the manpower and training needs of treatment plant operators in New England. During the summer of 1968, an on-site survey was conducted at 130 non-industrial treatment plants, ranging in capacity from less than 500,000 gallons a day to 350 million gallons a day, including primary, secondary and a few tertiary plants. The purpose of the survey was to gather information on the existing manpower resource, salaries, and previous training of operators responsible for the operation of control facilities. This information has been used as a basis for developing recommendations for action at Federal, State and local levels related to salary levels, training needs, certification and recruitment. Specifically, the report presents an estimate of the existing manpower resource and future needs; compares the salaries of operators with those in comparable occupations; evaluates existing and future training needs; assesses present certification and recruitment programs; and makes recommendations for action to meet the manpower requirements for effective, efficient operation of water pollution control facilities in New England.

SUMMARY OF FINDINGS

The number of chief operators, operators and assistant operators in New England was estimated to be approximately 1,160 operators at 397 non-industrial plants based on the 1968 survey and the 1968 municipal waste inventory. This estimate includes only those involved with the actual operation of the treatment plants, and does not include laborers and tradesmen, such as electricians and mechanics, supervisory professional staff or laboratory technicians.

In addition to the present number of operators in New England, over 1,400 will be needed by 1977 to staff those plants required by water quality standards for all interstate and most intrastate waters of each New England State. This estimate does not include the additional number of operators who will be needed to fill present vacancies, and future vacancies which will occur due to retirement and normal attrition.

The average weekly salaries in New England (based on the 1968 survey) were $150 for chief operator, $116 for an operator, and $106 for an assistant operator. Weekly salaries in plants surveyed ranged from $99 to $240 for a chief operator, from $83 to $207 for an operator, and from $73 to $143 for an assistant operator. Average weekly salaries of occupations in industry comparable to chief operator, operator and assistant operator were $194, $157 and $140 respectively.

Efforts to train operators have been limited in recent years, ranging from no scheduled training to only a few scheduled training courses. All short courses were designed to upgrade the skills of presently employed operators. No formal training has been available in New England until

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very recently. Estimates indicate that between 800-1,000 of the future operators will need formal training, and approximately 500-700 future operators should receive short course training in the next 8-10 years. Further, it is estimated that between 800-1,000 operators presently employed will need additional training as many have not received adequate training.

Connecticut, Maine and New Hampshire are the only New England States with mandatory operator certification legislation. The other three States utilize a voluntary program conducted by the New England Water Pollution Control Association. Massachusetts has proposed legislation this year for mandatory certification.

New England faces a major problem in recruiting competent and qualified personnel to operate its wastewater treatment plants. Most plants do not have any systematic recruitment program.

The effectiveness of the total water pollution control program in New England relies on the number of qualified operators responsible for the proper and efficient operation of existing and future wastewater treatment plants. To recruit and retain qualified operators, salaries must be upgraded, adequate training must be offered, mandatory certification must be enacted, and an effective recruitment program must be developed and implemented.

RECOMMENDATIONS FOR ACTION

To meet the manpower and training needs for wastewater treatment plant operators in New England, local, State and Federal governments can help in the following ways:

1. Local officials:

   a. become informed of the complexity and problems associated with a treatment facility,

   b. upgrade operators' salaries to be competitive with comparable occupations in private industry,

   c. recruit competent treatment plant personnel,

   d. provide funds sufficient to properly operate and maintain the facilities and effectively train new and present operators,

   e. support the establishment of regional operating districts responsible for the proper operation and maintenance of several treatment facilities within the region.

2. State officials:

   a. sponsor a short course (7-15 hours) for local officials in waste treatment,

   b. assist local officials in recruiting competent operators and upgrading salaries,

   c. require adequate training of treatment plant personnel,

   d. support regional training programs as well as sponsor State training courses for operators,

   e. introduce operator training in junior colleges and technical schools,

f. encourage the passage of mandatory certification legislation,

g. support the establishment of regional operating districts,

h. consider requiring applicants requesting State construction funds to submit a more detailed list of personnel to staff their facility, including duties and salary ranges for each classification.

3. Federal officials:

a. Continue to:

(1) assist in the development of curricula in junior colleges and technical schools designed to train treatment plant personnel,

(2) support and assist technically in regional and State training programs,

(3) develop new and updated guides on optimum staffing patterns for various sizes and types of facilities,

(4) encourage the passage of mandatory State certification legislation,

(5) encourage the establishment of regional operating districts.

b. Plan to:

(1) promote the understanding of operator's role by such activities as:

(a) preparing, in cooperation with State agencies and consultants, a handbook of standard titles and classifications of operators,

(b) preparing a career brochure on operator needs and opportunities for national distribution,

(2) assist in furthering greater public awareness by such measures as expanding the national public information and education program to include treatment plant operation -- acquainting the public and

prospective employees with the ramifications of training, skills required, benefits to be derived, and losses to be incurred if plants are not properly operated,

3. improve the quality of instruction available for waste treatment operators by such methods as providing instructor training courses for New England.

c. Consider requiring applicants requesting Federal construction funds to submit, in addition to presently required information on personnel and expenditures, a more detailed list of personnel to staff their facility, including duties and salary ranges for each classification.

GENERAL BACKGROUND

The Federal Water Pollution Control Act, particularly as amended by the Water Quality Act of 1965 and the Clean Water Restoration Act of 1966, has provided the framework for an accelerated water pollution control program for the Nation. Two important provisions of the Water Quality Act are (1) a requirement for setting water quality standards for interstate waters, and (2) the increase of Federal participation in construction grants to local communities for water pollution control facilities. The 1966 Act further increased authorizations for construction grants.

The 1965 Act required that all States establish water quality standards applicable to interstate (including coastal) waters before June 30, 1967. These standards were to include water quality criteria and implementation and enforcement plans, and were to be officially adopted as Federal standards after the Secretary of the Interior had determined that the State criteria and plans were consistent with the purposes of the Act, i.e., "...to enhance the quality and value of our water resources and to establish a national policy for the prevention, control and abatement of water pollution."

The water quality standards are based on water uses and include specifications on such parameters as dissolved oxygen, sludge deposits, solid refuse, floating solids, oils and grease scum, color, turbidity, coliform bacteria, taste and odor, pH, allowable temperature increase and chemical constituents.

The costs of implementing the water quality standards are shared by Federal, State and local governments. Since 1956, when the Act was first passed, a Federal grants program has allocated money to States, municipalities, and inter-municipal or interstate agencies to assist in the

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planning and construction of municipal waste treatment works to prevent the discharge of untreated or inadequately treated sewage or other waste into any waters. Projects that are eligible for grants under the Act include new construction and/or extensions, alterations, renovation of treatment works, interceptor sewers, outfall sewers, and certain pumping stations and force mains appurtenant to the interceptor system.

Since water pollution control facilities are expensive and complex public works, they must be properly designed, constructed, operated and maintained to protect the public investment, and to serve the purposes for which they were intended, i.e., protecting public health and improving the quality of receiving waters. It is the responsibility of local, State and Federal officials to assure that these needs are met. Furthermore, Section 8(b) of the Federal Water Pollution Control Act, states that:

> "...no grant shall be made for any project...until the applicant has made provision satisfactory to the Secretary [of the Interior] for assuring proper and efficient operation and maintenance of the treatment works after completion of the construction thereof."

To assure compliance with this requirement, the Federal Water Pollution Control Administration (FWPCA) and the appropriate State officials conduct an audit of all plants constructed with Federal funds one year after the plant has been in operation. Three years after the initial audit, a select sample of the plants is re-audited.

The operation and maintenance of treatment facilities is the primary responsibility of local officials and citizenry. The States have played a major role in the operation of such facilities by providing technical assistance to communities, by sponsoring training courses for operators, and by inspecting the plants periodically. The State's role is increasing greatly with the construction of many new complex plants.

Many local officials have little awareness of the complexity of treatment facilities and the importance of hiring qualified operators. Salary scales have been low and operator training opportunities have been limited. Consequently, many facilities are not operated efficiently.

DEFINITION OF TERMS

Water Pollution Control Facility: The facility where municipal and/or industrial wastes receive treatment before being discharged into a waterway. Also called a wastewater treatment plant.

Primary Treatment: A waste treatment process that removes settleable and floatable solids and approximately 35 percent of the organic pollutants by a physical process, usually sedimentation.

Secondary Treatment: A waste treatment process that removes settleable and floatable solids and approximately 80-95 percent of the organic pollutants by a biological process, usually following primary treatment.

Tertiary Treatment: A third level treatment that may remove up to 99 percent of the organic pollutants in wastewater. Tertiary treatment follows primary and secondary treatment and consists of an additional physical, chemical or biological process. (Recent research indicates that the secondary process may be eliminated.)

Chief Operator: One who is responsible for the proper and efficient operation of a treatment plant, and who has administrative and supervisory functions as well.

Operator: One who is in charge of the operation of a treatment plant, but with little or no supervisory responsibilities.

Assistant Operator: One who assists in the operation of a treatment plant under the general supervision of an operator of higher grade.

Comparable Occupations: Occupations in private industry similar to operational positions at a wastewater treatment plant, and which require men having comparable skills to those of treatment plant operators. For example,

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comparable positions in industry for the chief operator category include foreman and supervisor in utilities; master plumber, mechanic and electrician; petroleum stillman (chief operator); and electrical dispatcher.

Mandatory Certification: Requirement that operators meet certain educational and experience requirements set by a State board before they are permitted to operate a wastewater treatment plant.

MANPOWER

The manpower resource discussed in this report is limited to those people involved with the actual operation of water pollution control facilities and does not include laborers and tradesmen, such as electricians and mechanics, supervisory professional staff or laboratory technicians. This section presents estimates of the existing number of treatment plant operators in New England as well as future needs. Present and future classifications and qualifications of operators are also discussed.

Present Resource

Number Estimates of the existing number of wastewater treatment plant operators in New England are based on the 1968 survey and the 1968 inventory of municipal waste facilities prepared by the New England States and FWPCA. For the purpose of this report operators were classified into three categories: (1) chief operator, (2) operator, and (3) assistant operator.

Table 1 presents the estimated number of chief operators, operators and assistant operators for each New England State as well as totals for New England. Approximately 1,160 operators run 397 plants throughout New England. The figures in Table 1 do not include operators in charge of industrial treatment plants. However, they do include institutional plants, such as schools or hospitals; private facilities, such as trailer courts, shopping centers or motels; and Federal installations constructed prior to 1965.

TABLE 1

EXISTING MANPOWER RESOURCE OF NON-INDUSTRIAL WASTEWATER TREATMENT PLANT OPERATORS IN NEW ENGLAND

(1968 Estimates)

State	Chief Operator	Operator	Assistant Operator	Total	Plants
Connecticut	70	200	165	435	110
Massachusetts	30	200	150	380	127
Rhode Island	15	75	50	140	36
Maine	5	50	10	65	47
New Hampshire	20	35	15	70	35
Vermont	10	45	15	70	42
New England Totals	150	605	405	1,160	397

Classifications A wide variety of job titles is being used in New England for wastewater treatment plant operators of the same category. For example, the following titles are used in the New England plants surveyed: Sewage Treatment Plant Operator, Maintainer I and II, Foreman, General Foreman, Water and Waste Processing Specialist and Attendant. For contrast, the titles in the Dictionary of Occupational Titles, U. S. Department of Labor, are Sewage - Disposal Worker, Sewage - Plant Attendant, Sewage - Plant Operator and Senior Sewage - Plant Operator. It is evident that presently there are no standard classifications for wastewater treatment plant operators.

Qualifications Present qualifications for operators vary widely depending on plant size and treatment type. At many small plants in New England there are no minimum qualifications. The larger plants have job descriptions for each position at the plant which specify the duties and qualifications for each position. Examples of the qualifications for a chief operator, operator and assistant operator at a large primary treatment plant in New England are as follows:

Chief Operator

1. Thorough knowledge of wastewater treatment plant operation and practices in the specialization assigned;
2. Considerable knowledge of applicable laws, regulations and practices applied to the administration of a water pollution control facility;
3. Ability to establish and maintain effective working relationships with associates, subordinates and the public;
4. Ability to supervise and coordinate investigations involving the application of health laws and regulations;
5. Ability to express ideas clearly and concisely, orally and in writing;
6. Ability to understand and follow complex written and oral instructions;
7. Considerable progressively responsible operational experience in the field involved; and
8. Thorough knowledge of accepted safety practices.

Operator

1. Considerable knowledge and experience in the operation of large highly mechanized primary wastewater treatment plants with sludge treatment and digestion;
2. Considerable knowledge of the operation of diesel and dual fuel engines and the application of mechanical equipment to the treatment of wastewater;
3. Working knowledge of the principles and practices of wastewater treatment;
4. Ability to establish and maintain effective working relationships with associates, subordinates and the public;
5. Ability to understand and follow written and oral instructions;
6. Ability to express ideas clearly and concisely, orally and in writing;
7. Ability to keep records and to prepare reports of treatment procedures; and
8. Thorough knowledge of accepted safety practices.

Assistant Operator

1. Working knowledge of safety practices in the operation of electrical and mechanical equipment used in wastewater treatment;
2. Working knowledge of the methods, practices and techniques used in operation of electric motors, controllers, engines, pumps, collection and conveying equipment, screens, chlorinators and grinders;
3. Some knowledge of primary wastewater treatment and treatment plant equipment;

4. Ability to operate various types of equipment used in the wastewater treatment process in accordance with established procedures;
5. Ability to follow oral and written instructions; and
6. Thorough knowledge of accepted safety practices.

In addition to the above qualifications, some plants require that a chief operator have an associate degree in engineering and that an operator at least a high school education.

Future Needs

Number In addition to the present number of operators in New England, approximately 1,450 will be needed by 1977 to staff those plants called for in the water quality standards for all interstate and most intrastate waters developed by each New England State. Table 2 presents estimates of operators needed for each New England State and New England totals for each type of operator. The breakdown by category for the 1,450 men during the next 8-10 years is 135 chief operators, 815 operators and 500 assistant operators.

Figure 1 represents the estimated additional number of operators who will be needed in New England for each year from 1969-1977. The totals for each year range from a high of 335 in 1970 to a low of 35 in 1977. These estimates are believed to be conservative and do not include operators needed to staff those treatment plants not included in the water quality standards' implementation schedules for some of the New England States. Some States did not include treatment plants that would discharge into intrastate streams.

Beyond the number of operators to staff new and expanded wastewater treatment plants, additional operators will be required to fill those positions falling vacant due to retirement and normal attrition. For

example, the average age of operators interviewed was 46 for Connecticut, 50 for Massachusetts, 48 for Rhode Island, 45 for Maine, 48 for New Hampshire and 47 for Vermont. The survey results show that 27 percent of the 164 operators interviewed were 55 years of age or older. If this percentage prevails throughout New England, then approximately 300 operators will be eligible for retirement in the next 8-10 years.

TABLE 2

ADDITIONAL WASTEWATER TREATMENT PLANT OPERATORS

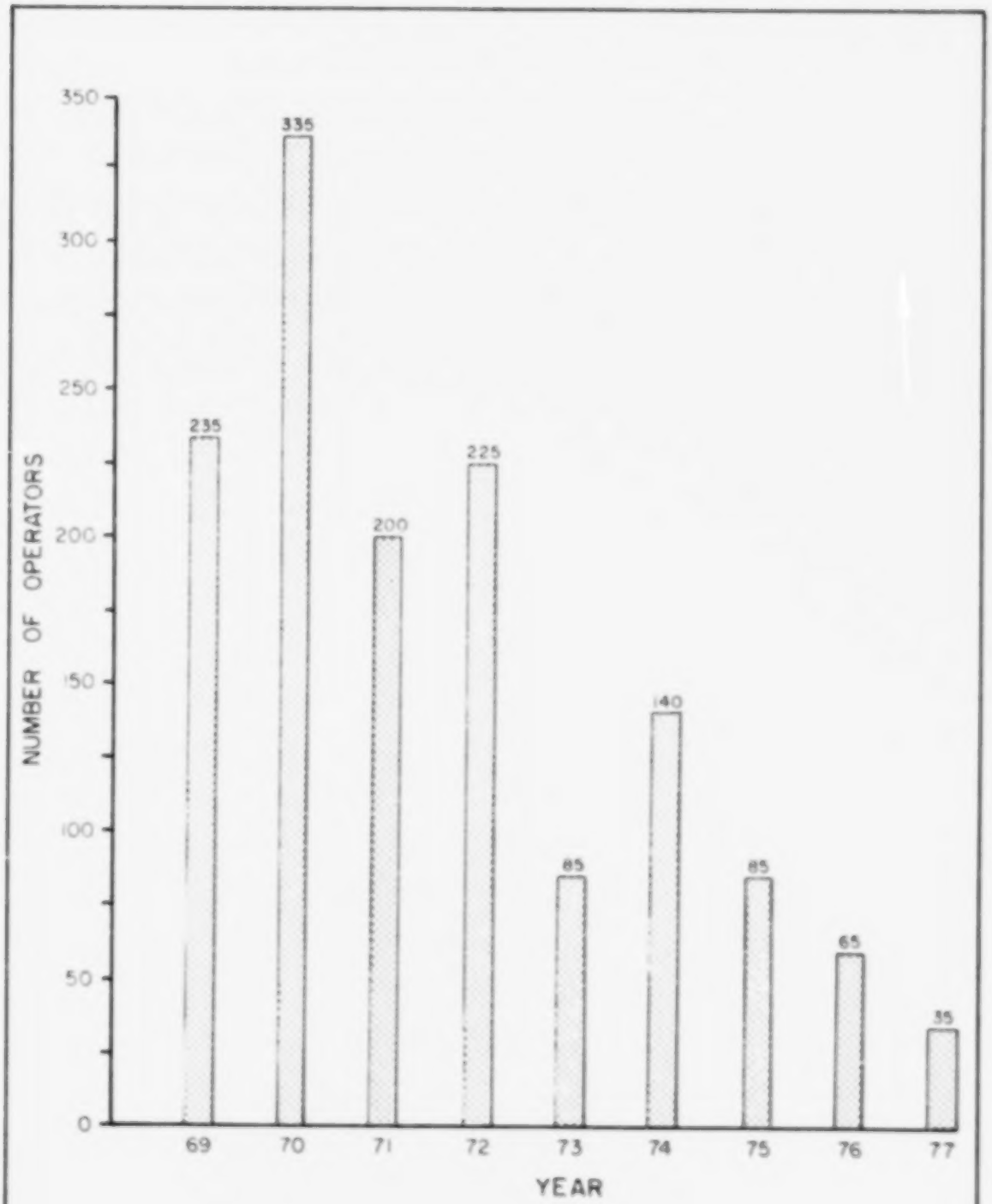
REQUIRED IN NEW ENGLAND

BY 1977*

State	Chief Operator	Operator	Assistant Operator	Total
Connecticut	20	190	90	300
Massachusetts	50	270	160	480
Rhode Island	5	15	10	30
Maine	40	210	150	400
New Hampshire	15	100	65	180
Vermont**	5	30	25	60
New England Totals	135	815	500	1,450

* The number of operators required in addition to the existing number in New England to staff municipal plants. Estimates do not include future vacancies due to retirement and normal attrition.

** State estimate - Chief Operator 11, Operator 41, Assistant Operator 11, total 63.



ADDITIONAL WASTEWATER TREATMENT PLANT OPERATORS REQUIRED IN NEW ENGLAND BY 1977

2CA **FIGURE 1**

Classifications and Qualifications To eliminate present confusion, acceptable job classifications for treatment plant operators should be developed. In addition, criteria should be developed for the qualifications of each classification or job category relative to general education, physical condition, aptitudes and specific vocational training.

Presently, the Federal government is expanding the Dictionary of Occupational Titles concerning occupational categories and qualifications of wastewater treatment plant operators. A handbook on occupational categories and qualifications would be useful in determining future manpower and training needs, and in helping local officials to recruit the best personnel. FWPCA, in cooperation with State agencies and their consultants, plans to undertake the development of such a handbook.

SALARIES

Salary levels are of primary importance in recruiting and retaining qualified operators for wastewater treatment plants. Salaries must be competitive with private industry since people with the necessary skills have a wide selection of occupations from which to choose. Their industrial options pay considerably more than do New England's wastewater treatment plants.

New England Survey Findings

In 1968 a salary survey of non-industrial treatment plant operators of New England was conducted. The average weekly salaries for each State and for New England as a whole, for chief operator, operator and assistant operator are shown in Table 3.

TABLE 3

AVERAGE WEEKLY SALARIES AT

NON-INDUSTRIAL TREATMENT PLANTS IN

NEW ENGLAND

(1968)

State	Chief Operator	Operator	Assistant Operator
Connecticut	$163	$127	$114
Massachusetts	141	122	113
Rhode Island	134	105	96
Maine	-	97	78
New Hampshire	139	106	93
Vermont	142	116	98
New England	150	116	106

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Salaries range widely. The low was $73 for an assistant operator, the high $240 for a chief operator. Connecticut's average salaries were the highest of all New England States for all three types of operators and Maine's the lowest for an operator and an assistant operator. The weekly average salaries for New England were $150 for a chief operator, $116 for an operator and $106 for an assistant operator. The minimum and maximum weekly salaries for all plants in the survey were $99 and $240 respectively for a chief operator, $83 and $207 respectively for an operator, and $73 and $143 respectively for an assistant operator.

Table 4 shows salary ranges of operators in each New England State for various sizes and types of treatment plants. At the plants listed in the table the salary figures in each column represent either salaries for one or more operators of similar responsibility at the same plant or the range of salaries for a certain category of operators at plants having the indicated waste flow capacities. As can be seen from this table, the size of the plant or kind of operation has little to do with the salary. (A chief operator in charge of a secondary plant in Connecticut ranging between 3.5 - 7.0 mgd receives considerably more than a chief operator in Massachusetts at a plant ranging between 20.0 - 25.0 mgd.)

TABLE 4

SALARIES OF WASTEWATER TREATMENT PLANT OPERATORS IN NEW ENGLAND

State	Flow (mgd)	Type of Treatment	Weekly Salary Range		
			Chief Operator	Operator	Assistant Operator
Connecticut	0.1-0.5	Primary	-	$110-151	$110-135
		Secondary	$130-240	100-171	100-120
	0.7-1.5	Primary	130-173	104-134	115-120
		Secondary	160-194	92-140	100-120
	3.5-7.0	Secondary	138-195	100-150	102-110
	7.5-15.0	Primary	135-144	126-144	115-122
	17.0-25.0	Primary	124-192	108-159	92-127
	42.0	Primary	160-206	132-150	132-143
Massachusetts	0.1-0.5	Secondary	-	100-150	84-128
	0.7-1.5	Primary	115-130	99-127	99-127
		Secondary	110-154	100-136	112
	3.5-8.5	Primary	99-129	99-110	-
		Secondary	130-156	103-122	104
	20.0-25.0	Primary	130-156	113-137	98-119
		Secondary	126	104	-
	140.0	Primary	132-167	122-155	107-136
	350.0	Primary	185-235	163-207	107-136
Rhode Island	0.3-0.7	Secondary	116-121	90- 94	-
	1.0	Primary	-	117	105
	5.0-6.0	Secondary	163	95-120	112
	16.0	Primary	110-134	94-104	82- 90
	45.0	Secondary	140	83- 92	-
Maine	0.1-0.5	Primary	-	85-100	73
	1.0-3.5	Primary	-	86-132	80
New Hampshire	0.1-0.5	Secondary	-	88-115	-
	0.7-1.5	Primary	140-143	100-130	120
	2.0-4.0	Primary	114-150	90- 91	82- 91
Vermont	0.5-2.0	Primary	130-134	100-122	100
		Secondary	-	132	74
	4.0-5.0	Primary	136-168	109-120	97

National Survey Findings

The FWPCA conducted a limited national survey of 14 large wastewater treatment plants in November 1968. Data obtained in this survey included salaries, personnel vacancies if any, job qualifications and benefits. The salary data are presented in Table 5. The survey found that those plants offering salaries comparable to private industry have no problem recruiting qualified personnel. In fact, some of the better paying plants have a waiting list for certain positions.

TABLE 5

SALARIES OF WASTEWATER TREATMENT PLANT OPERATORS

IN THE

UNITED STATES

Geographical Area	Flow (mgd)	Type of Treatment	Weekly Salary Range		
			Chief Operator	Operator	Assistant Operator
East	300	Primary	$195	$184	$170
	150	Primary	245	173	125
	170	Secondary	139-154	122-132	105-116
Midwest	300	Secondary	198-298	163-243	149-219
	200	Secondary	316-384	268-288	185
	173	Primary	172-210	142-156	129-142
	117	Secondary	160-210	132-173	117-153
	85	Primary	150-190	123-157	106-135
	34	Primary	156-200	142-170	120-156
West	420	Primary	249-310	179-223	136-170
	400	Primary	194-242	170-210	152-189
	165	Primary	223-270	197-244	111-122
	50	Primary	197-219	150-168	139-155
Southwest	54	Primary	127-162	118-150	102-127

Comparable Occupations

After analysis of the qualifications necessary to operate treatment plants, a list of comparable occupations in private industry was compiled based upon education, background and general qualifications. These jobs in private industry are easily filled mainly due to the higher salary and greater fringe benefits while filling the jobs of waste treatment plant operators is difficult.

Treatment Plant Positions	Comparable Positions
Chief Operator	Foreman or supervisor in utilities Electrical dispatcher Master plumber, electrician and mechanic
Operator	Technician in utilities Power plant operator Control room operator Assistant petroleum stillman Chemical operator A
Assistant Operator	Assistant control room operator Chemical operator B Petroleum stillman - helper Light machine operator

Salary Comparison with Comparable Occupations

Average weekly salaries for New England treatment plant operators and people filling comparable occupations follow:

Occupation	Average Weekly Salary	Difference
Chief Operator	$150	$44
Comparable Occupation*	194	
Operator	116	41
Comparable Occupations	157	
Assistant Operator	106	34
Comparable Occupations	140	

* Salary data for petroleum occupations represent the East Coast rather than solely New England.

Yearly differences range from $1,800 to $2,300. These figures do not include the additional fringe benefits given by private industry.

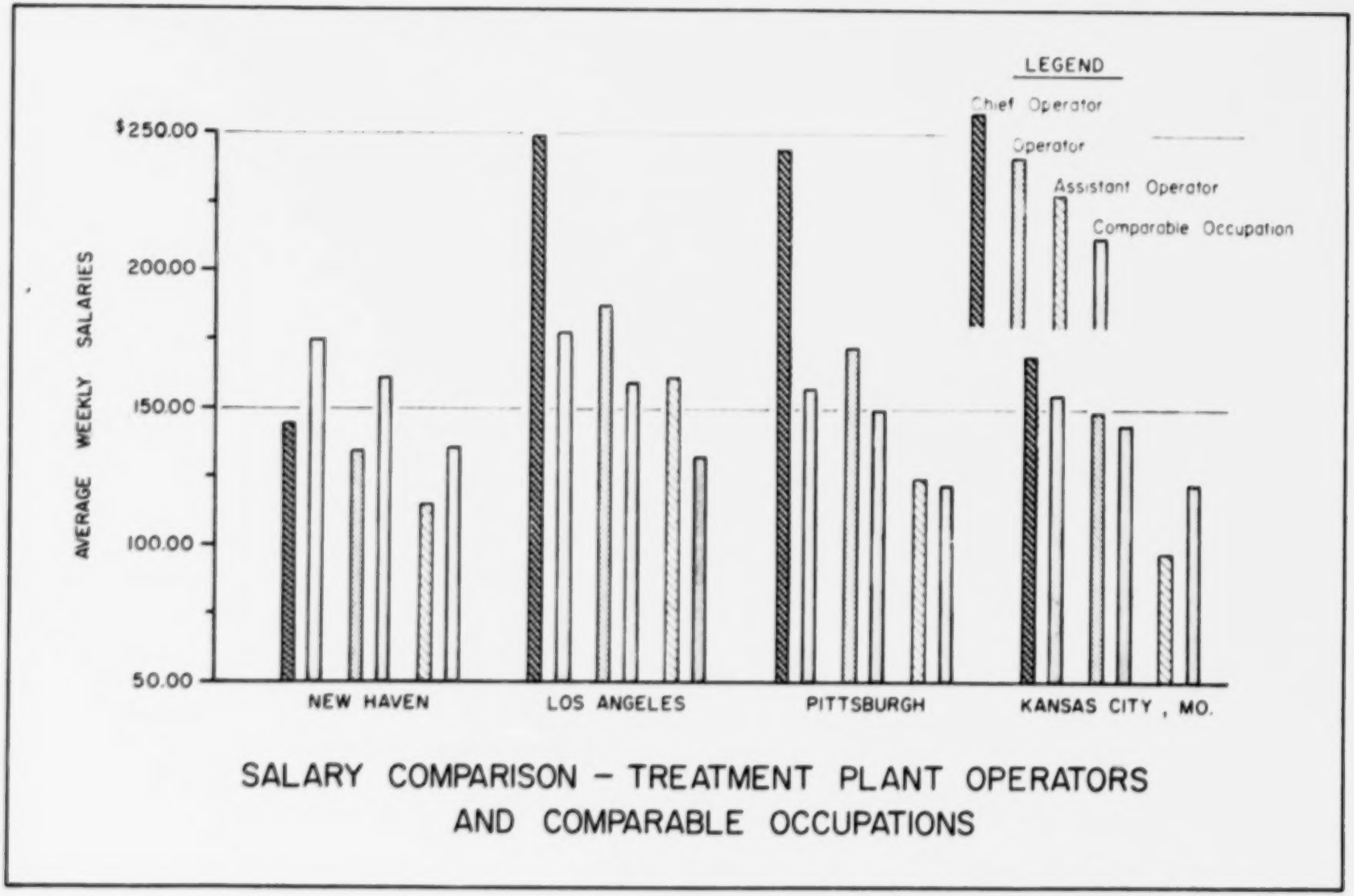
A similar salary comparison was made for four large cities: three cities taken from the national survey and one from the New England survey. The three nationally surveyed cities were chosen because their treatment plants pay the best salaries (Pittsburgh and Los Angeles) and the lowest salaries (Kansas City, Missouri) of the plants surveyed. New Haven, the fourth city, was selected from the New England survey for comparison.

Operator salaries in Los Angeles and Pittsburgh are considerably higher than comparable occupations, while the opposite is true for all categories in New Haven and the assistant operators in Kansas City. Furthermore, at the time of the survey, the Kansas City treatment facility was having difficulty in hiring competent operators while the Pittsburgh plant had a waiting list for certain positions. Figure 2 shows the salary relationships within and between the four cities.

Upgrading Salaries

Establishing salary levels is primarily the responsibility of local officials and voters. However, State, Federal and interstate agencies and other organizations, such as unions and the New England Water Pollution Control Association, can assist greatly. Since salaries must be raised to aid in better operator recruiting and retention, many in the water pollution control field have suggested methods for doing so as follows:

1. Inform local officials and citizens as to the complexity of a wastewater treatment plant, the need to hire qualified operators and the importance of competitive salaries to recruit and retain qualified operators. The State water pollution control agencies and consultants in plant design



SALARY COMPARISON – TREATMENT PLANT OPERATORS
AND COMPARABLE OCCUPATIONS

FIGURE 2

are in the best position to perform this function as they deal directly with the communities. This could include a short course (7-15 hours).

2. Enact legislation in Massachusetts, Rhode Island and Vermont requiring mandatory certification of operators in charge of operating treatment plants. Local citizens can assist by supporting such legislation.
3. Require that applicants requesting Federal and State construction funds submit, in addition to presently required information on personnel and expenditures, a more detailed list of personnel to staff their facility, including duties and salary ranges for each classification. Approval of grants would then depend upon adequacy of staffing pattern and salaries.
4. Prepare new and updated guides on optimum staffing patterns and salary ranges for various sizes and types of facilities. These guides would assist localities and States in planning more systematically for manpower requirements and in strengthening their budget requests. They would replace the 1963 guides, "Recommendations for Minimum Personnel, Laboratory Control and Records for Municipal Waste Treatment Works," by the Conference of State Sanitary Engineers.
5. Establish regional or Statewide operating districts for the efficient and proper operation and maintenance (not necessarily construction) of all treatment facilities within the region or State. By combining resources, the communities involved would be able to hire competent operators, pay each an adequate salary, provide more training and better advancement opportunities, and reduce the duplication of personnel and fully equipped laboratory facilities otherwise required to support each plant separately The scope of the proposed districts could be further increased to include developing capital programs and eventually owning the facilities.

TRAINING

The demand for trained wastewater treatment plant operators is increasing annually and will continue to do so with the completion of new complex treatment facilities. Efforts to train operators have been limited in recent years, ranging from none to only a few scheduled training courses. In addition, existing programs are designed to upgrade the skills of operators in the field without providing needed training for new operators. No formal training has been available in New England until very recently.

For these reasons, a careful reappraisal of all factors related to recruitment, retention and training of wastewater treatment plant operators in New England is necessary. This section summarizes existing programs and opportunities and assesses future training needs.

Existing Training Programs and Opportunities

Formal Training The complexity of today's modern wastewater treatment plants requires a staff of competent operators with relatively higher levels of education than in the past. The educational background of those operators interviewed varied from some with master's degrees to many who did not complete grammar school. Of the 164 operators interviewed, 36 (or 22 percent) attended one or more years of college, 75 (or 46 percent) completed high school, and 53 (or 32 percent) had not completed high school.

Emphasis should be to recruit operators with higher levels of education, i.e., a high school education plus some additional training in the operation and maintenance of treatment facilities. In larger treatment facilities, it is desirable to have some operators who are graduates of technical-vocational schools or junior colleges.

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However, only 20 technical institutes and colleges in the United States offer a two-year program in water and wastewater technology, some of which offer as much sanitary engineering as is offered in a four-year civil engineering program. Presently, no such program exists in New England although a few have been proposed.

Fayetteville Technical Institute in North Carolina offers a sanitary technology curriculum which emphasizes treatment plant operation. (See Appendix for outline of curriculum.) Of its 24 graduates last year, only one accepted employment at a wastewater treatment plant. The reason was better compensation elsewhere.

The Water and Wastewater Technical School in Neosho, Missouri has been offering 9 and 4 month courses in water and wastewater technology.

A suggested two-year post high school curriculum, "Water and Wastewater Technology", has been published by FWPCA and the Office of Education, U. S. Department of Health, Education and Welfare. This manual is to assist State and local governments in developing technician training programs.

Programs for vocational and technical training administered by Federal agencies offer substantial opportunities for providing specialized training for treatment plant operators. A brief summary of these programs follows:

Vocational Education Program. Training in specific occupational categories is offered by a vocational education program, administered by the U. S. Department of Health, Education and Welfare. Many basic and necessary skills needed in the operation of wastewater treatment plants can be met through this training.

During fiscal year 1964, 19.2 percent of all high school students were enrolled in some kind of Federally aided vocational education program.

Projections indicate that by 1970 at least 35 percent of all high school students will be enrolled in Federally aided vocational programs.

Community Service and Continuing Education Program The Higher Education Act of 1965 provides a wide latitude of training and educational activities at subprofessional levels. Courses can be established at any accredited public or private college or junior college. In fiscal year 1966, 301 higher educational institutions conducted 548 community services programs involving an estimated 14,000 participants. A number of States have used this program for training treatment plant operators.

Manpower Development and Training Program The Federal Manpower Development and Training Act (MDTA) provides training for unemployed and underemployed persons in both institutional and on-the-job training. The MDTA program, directed towards reducing skill shortages, offers considerable opportunity for training wastewater treatment plant operators in both classroom and on-the-job instruction.

Cooperative Area Manpower Planning System In March 1967, the Departments of Health, Education and Welfare; Housing and Urban Development; Labor; and the Office of Economic Opportunity established the Cooperative Area Manpower Planning System (CAMPS). The purpose of the program is to develop an interagency, intergovernmental multi-program approach to solving the Nation's technical manpower problems. CAMPS is essentially a planning system which relates the various program funds to the various manpower needs within a State. It functions by coordinating committees established at four levels: national, regional, State and area. These committees plan a coordinated interagency and intergovernmental program of technical manpower services, and assist in the implementation of program activities.

CAMPS provides the mechanism for Federal, State and local governments to provide classroom instruction coupled with on-the-job training, for both presently employed and new operators. The program is funded by Congress in fulfillment of education and manpower development legislation administered jointly by several Federal, State and local agencies.

Short Course Training The State agencies have been most active in sponsoring short courses or seminars for wastewater treatment plant operators. The 1967 Report of the Committee on Personnel Advancement, Water Pollution Control Federation,* indicated that 39 States offered one or more technical courses for treatment plant operators. These courses were reported to have enrolled about 11,000 attendees. Since these courses are not restricted to operators, the attendees include personnel of regulatory agencies, consulting engineers and suppliers.

Although these courses have made commendable strides in combatting poor plant operation, their long-term effectiveness is questionable. Most courses have been designed and conducted by already overburdened employees of State regulatory agencies, consultants and volunteers, and have received insufficient financial and educational support. Weakness of these programs may result from lack of evaluation when training is actually going on and from lack of adequate follow-up. Many training programs try to teach too much, too intensively, in too short a time. The result is that many operators leave the course with "academic shell-shock".

The training opportunities available to New England operators in recent years have been limited. A summary of the training courses available to operators in New England prior to July 1968 follows:

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* "1967 Status of Operator Training and Certification in United States", Journal of the Water Pollution Control Federation, Vol. 40, No. 7, 1968, page 1,332.

Connecticut	- Six one-week courses, six evening courses, four one-day seminars, five 21-hour laboratory courses, and two 36-hour laboratory training courses.
Massachusetts	- a two-week course and two one-day per week courses for eight weeks. A five-month course of 15 hours per week sponsored by the Metropolitan District Commission.
Maine	- three one-week courses.
New Hampshire	- No training courses in recent years. At each quarterly meeting, New Hampshire Water Pollution Control Association devotes some time to an educational program on plant operation.
Rhode Island	- six evening courses each consisting of 80-hours, two two-hour sessions per week for 20 weeks.
Vermont	- no training courses.
NEIWPCC*	- three one-week in-service training courses at Topsfield, Massachusetts.

Training courses conducted in New England during FY 1969 were:

Connecticut	- one 21-hour and one 36-hour laboratory training course, one 36-hour basic theory training course, one 30-hour secondary theory training course, and one 1-day seminar for treatment plant superintendents and operators.
Massachusetts	- one 32-week evening training course totalling 64 hours and a 12-month course sponsored by Metropolitan District Commission.

* New England Interstate Water Pollution Control Commission.

Maine	- none.
New Hampshire	- none, other than the training conducted at New Hampshire Water Pollution Control Association meetings.
Rhode Island	- one 80-hour evening training course.
Vermont	- a 2-day course.
NEIWPCC	- two basic, two intermediate and one advanced one-week courses at Topsfield, Massachusetts.
FWPCA	- one three-week training course in South Portland, Maine, August 1968.

In the process of visiting the treatment plants throughout New England, a total of 164 operators were interviewed to obtain more specific information relating to their positions, including the number of training courses each operator has attended. Results show that approximately 21 percent or 34 of the operators interviewed have not attended any type of training course, and another 23 percent or 37 have attended only one training course. Of the 164 operators interviewed, 59 percent or 96 have attended at least one one-week training course. Of those interviewed in Connecticut, only 4 percent reported not having attended any training course compared to 64 percent in Vermont. Table 6 presents figures on the training courses attended by the operators interviewed in each New England State.

Based on these findings, approximately 250 of the existing 1,160 operators in New England have not attended any type of course, and another 250 to 300 have probably only taken one training course.

The Water Pollution Control Federation has contributed much to improving the skills of wastewater treatment plant operators by: (1) providing training

TABLE 6

TRAINING COURSES ATTENDED

BY

OPERATORS INTERVIEWED IN NEW ENGLAND

State	Operators Interviewed	1-Week Course*		2-Week Course or Longer		Evening Course		1 Day/Wk For 7-13 Weeks		No Courses		Only One Course	
	No.	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Connecticut	51	40	78	7	14	15	29	10	20	2	4	6	12
Massachusetts	48	23	46	6	12	6	12	6	12	15	30	9	18
Rhode Island	16	8	50	4	25	2	12	0	0	1	6	8	50
Maine	18	14	79	1	6	0	0	0	0	3	17	9	50
New Hampshire	17	7	42	3	18	0	0	0	0	4	23	4	23
Vermont	14	4	28	2	14	0	0	0	0	9	64	2	14
New England	164	96	59	23	14	23	14	16	10	34	21	38	23

* 29 operators have taken more than 1 one-week course.

course materials including extensive visual aids (beginner and intermediate levels available), (2) encouraging the development of State training programs, (3) administering financial grants for training funded by the Water and Wastewater Equipment Manufacturers Association, Incorporated. Ninety-five treatment plant operators during 1968 from 21 States and Puerto Rico received funds totalling $10,065 with the average individual grant approximating $106. This year the Federation is continuing its grants program and, as of June, 31 operators have received financial assistance.

The Federal Water Pollution Control Administration plays a direct role in short course training through: (1) encouraging stronger State training efforts, (2) offering training courses for operators at certain FWPCA regional laboratories, and (3) assisting the States in course design and the development of training aids.

Future Training Needs and Opportunities

Formal and short course training of New England operators will be urgently needed to assure the proper and efficient operation and maintenance of the many new plants under construction or in the planning stages (just as the need exists right now for plants already operating). As mentioned, over 1,450 operators will be needed to staff those plants required by the water quality standards. An estimated 800-1,000 of these new operators should have some formal training concentrating on treatment plant operation.

In addition, short course programs should be designed to upgrade skills of those operators presently employed and those who enter the field at the assistant operator level or lower. Curricula should include coupled classroom and on-the-job training, so designed that over a period of time the

the attendee would receive training equivalent to that of an associate degree program or receive an advanced certification rating.

Formal Training In the future, formal training will become available to wastewater treatment plant operators in New England. The regional school being established at Southern Maine Vocational Technical Institute and the proposed two-year technical schools will serve to fulfill part of the formal training needs of New England.

Technical-Vocational School Two-year technical graduates (junior college level) to staff many of the proposed treatment facilities will continue to be needed. In general, it is preferable for chief operators in medium size plants to have attended a two-year technical school.

A number of the New England States are presently considering the establishment of a two-year environmental program. Maine has proposed a two-year program in water and wastewater technology to be offered at the Eastern Maine Vocational Technical Institute in Bangor, Maine. (The program has been approved by the Maine Department of Education, but has not been funded by the State Legislature.) The program will take two to four years before it is operational and at that time will be able to accommodate 30 students per year. The graduates would receive an associate degree and would be qualified to operate a wastewater treatment plant. Connecticut has proposed an environmental program to develop technicians in the environmental sciences. These graduates will need additional training in the day-to-day operation of a treatment plant if they are to be employed at a treatment facility.

Experience from a number of existing two-year schools indicates that graduates are not likely to accept positions in treatment plants since they

will probably be offered higher salaries and more attractive benefits elsewhere. There is a need for two-year schools in New England, but such schools will not benefit the wastewater treatment field unless operator salaries are competitive with Federal and State government and private industry which also demand two-year graduates.

New England Regional Wastewater Institute The New England States and the New England Interstate Water Pollution Control Commission are establishing a regional institute to train personnel not presently in the wastewater treatment field at the Southern Maine Vocational Technical Institute in South Portland, Maine. This site was selected to take advantage of the facilities and resources of an already existing vocational school. The school's training period is expected to be 9 months long. (See Appendix for course outline.) A total of 35 students can be accommodated. Trainees will receive a certificate upon completion of course.

Short Course Training Short course training of wastewater treatment plant operators in New England will be needed indefinitely. However, the effectiveness of such programs depends upon several considerations, including the type of courses offered and the amount of supervised on-the-job training provided.

A number of the New England States will continue short course programs, as summarized here:

Connecticut - The same courses in fiscal year 1970 as 1969 and participation in the future courses sponsored by the NEIWPCC.

Massachusetts	-	Evening courses similar to the one offered at Worcester Junior College at two other institutions and participation in the future courses sponsored by the NEIWPCC.
Maine	-	A ten-week evening course and participation in NEIWPCC training program.
New Hampshire	-	A 20-week course consisting of one day of classroom instruction and four days per week of supervised on-the-job training and participation in future courses sponsored by NEIWPCC.
Rhode Island	-	Considering an advanced course to supplement the course offered in fiscal year 1969 and participation in NEIWPCC training program.
Vermont	-	Participation in future courses sponsored by NEIWPCC.
NEIWPCC	-	Six one-week courses planned for fiscal year 1970.
FWPCA	-	Will continue to assist States to take advantage of CAMPS.

To meet the present and future training needs of treatment plant operators, it is necessary to provide a variety of short courses in New England. These may consist of 1 to 3 week training courses, evening courses, day courses (1 or 2 days a week for a number of weeks), and correspondence courses. Each type of course has advantages and disadvantages. For example, many operators cannot leave the plant to attend a 1 to 3 week course offered in another State, especially during the summer months. However, these same operators may be in a position to attend an evening course offered within commuting distance of their homes. The disadvantages of 1 to 3 week courses are: (1) too much material in too short a time, (2) effectiveness of training

cannot be measured, and (3) administrative difficulties with overtime pay necessary to compensate for one less man at the plant, which is a real problem at some plants. The disadvantage of an evening course is that many operators have part-time evening jobs, and are not able to attend. A number of operators interviewed indicated an interest in taking a correspondence course.

A preferred short course would offer classroom instruction during working hours at a plant, possibly one day a week for a number of weeks, in tandem with supervised on-the-job training. In the more urbanized areas of New England, the classroom instruction could be offered at a large plant with operators from surrounding plants attending. The instructor would supervise each trainee at his respective plant for the on-the-job aspects of training.

FWPCA has prompted efforts through the Manpower Development and Training Act to activate the kind of short course described, and arrangements are underway in New England to put on a program next year. The course would probably consist of 30 consecutive weeks of classroom instruction linked with on-the-job training (one day a week of classroom instruction and four days a week of supervised on-the-job training).

Coupled classroom and on-the-job training is the key to adequate plant operation. The training extends for a longer, more practical period of time, classroom instruction provides the background needed to assimilate detailed training more rapidly and meaningfully, and the supervised on-the-job training provides the natural environment in which to apply and evaluate the classroom instruction. Such a program is expected to offer an effective means of upgrading the skills of beginning and partially trained treatment plant operators during the next few years.

In those cases where it is impossible to have coupled classroom instruction and on-the-job training, then a short course training program should consist of: (1) 1 to 3 week courses for those interested in a short course, (2) evening courses for those not able to attend day courses, (3) correspondence courses for operators in some rural areas where it would be difficult to provide classroom instruction, and (4) one or two day-long seminars per year dealing with special operational problems. The program should be designed so that all operators will have an opportunity to upgrade themselves without causing extreme inconvenience to them or their employers. Furthermore, each short course offered would be part of a well planned program leading to an associate degree or advanced certification rating.

In summary, of the 1,450 new operators needed in the next 8 to 10 years in New England, 800-1,000 chief operators and operators will need formal training and 500-700 assistant operators will require short course training. Therefore, assuming a minimum of 800 new operators should be formally trained and 500 will require short course training in the next 10 years, then an average of 80 chief operators and operators and 50 assistant operators per year will need to be trained. However, there will be some years when more than double those numbers should be trained.

If retirement and normal attrition are taken into account, then the total number of new operators needed may range between 1,800 and 2,000, of which 1,000-1,300 men will require formal training and 700-800 men will require short course training. Therefore, in the next ten years an average of 100-130 chief operators and operators per year should have formal training and 70-80 assistant operators per year should have short course training.

In addition, between 800-1,000 operators presently employed will need additional training in the next three years. If the MDTA program continues through 1972 as planned, then it will be necessary to train 250-300 operators per year in New England.

According to present calculations, the training outlined above is the minimum needed in the future to help meet the critical training needs of wastewater treatment plant operators in New England.

CERTIFICATION

To date, twenty-three States have mandatory certification programs for their wastewater treatment plant operators. Twenty-four States conduct voluntary certification programs and three States have no program. The State of New Jersey has required mandatory examination and certification of wastewater treatment plant operators for the past fifty years.

Present Mandatory Programs

Connecticut, Maine and New Hampshire are the only New England States with mandatory certification legislation and their programs are still in the planning stage. The other three States follow a voluntary program conducted by the New England Water Pollution Control Association (NEWPCA).

Massachusetts proposed legislation in 1968, which did not pass, to establish a certification board for personnel of water and wastewater treatment facilities. The legislation would have required that by July 1971 all operators in charge of wastewater treatment plants be certified by the board. Another bill has been submitted in the 1969 Legislature.

Connecticut's mandatory certification program is similar to the NEWPCA's voluntary certification program with the exception of a provision for an operator-in-training. This would permit an applicant for Grade I, II or III certification as a wastewater plant operator to take an examination in a given class and become an operator-in-training if he submits evidence of education or experience in technical fields other than wastewater works. An operator-in-training is required to meet all the prerequisites for certification except experience requirements in wastewater works may be waived.

The States of Rhode Island and Vermont have not proposed mandatory certification legislation to date. However, the New England Interstate Water Pollution Control Commission has proposed supplemental statutes that would give the Commission the authority to act for the States in developing a regional certification program. The Commission submitted supplemental statutes to the legislatures of the member States in January 1969.

Present Voluntary Program

The NEWPCA initiated a voluntary certification program in 1957. As of May 1969, 341 operators have been certified. Of those certified, 215 are presently maintained on the active listing.

The objectives of the program are as follows:

"a) Improve the quality of wastewater treatment works operations,

b) Improve the status of wastewater treatment works operations,

c) Provide a roster of qualified personnel, and

d) Provide a means whereby those responsible for employment of wastewater treatment works operating personnel can readily determine the qualifications which are considered desirable in such personnel."*

Each plant in New England is classified by NEWPCA into categories based on the type and complexity of plant, the design population and, in some cases, the average population equivalent of the wastes treated. Seven grades are used in classifying the plants. Similarly, six grades of operators are established to parallel the classification of plants, not including Grade VII plants. Grade I certified operators are considered as qualified to

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* Journal of the New England Water Pollution Control Association, Vol. 1, October 1967, page 97.

supervise the operation of Grade I plants; Grade II certified operators, Grade II plants; etc.

A voluntary certification program has the advantage of general acceptance since one can take it or leave it. However, the disadvantage is that most States find that voluntary certification reaches only a maximum of 45 or 50 percent of the eligible plant operators. Smaller communities seldom become involved in such a program with the result that an unqualified man can be hired to operate the plant.

Future Programs Needed

It will be necessary in the future to implement a mandatory certification program in New England to assure that those in charge of wastewater treatment plants are qualified and trained operators. The advantages of a mandatory certification program are many, such as: (1) assuring that all plants are operated by certified operators, (2) developing a pool of certified operators, and (3) improving plant efficiency. The benefits to the operators are: (1) better salary scales, (2) recognition of status and responsibility, and (3) job security. That mandatory certification produces such benefits has been shown in a recent survey conducted by the Water Pollution Control Federation.*

The mandatory certification program for the New England States should require that each plant over a certain capacity have a minimum of one certified employee (person in charge). It may be preferable to require all operators to be certified. The program should be relatively simple to administer and should be flexible to permit operators to advance easily.

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* Journal of Water Pollution Control Federation, Vol. 40, January 1968, page 64.

In conclusion, mandatory State certification legislation supported by a training program should be passed in Rhode Island, Massachusetts and Vermont, since it is desirable for each State to adopt voluntarily a mandatory certification program that would include all plants in the State. FWPCA could assist the States in developing a standard national certification program.

RECRUITMENT

Present Methods

Another major problem confronting New England is recruitment of competent and qualified personnel to operate wastewater treatment plants. The importance of offering attractive and competitive salaries to potential employees has already been discussed but there are other difficulties beyond low salaries encumbering vigorous recruitment efforts.

Most plants do not have any systematic recruitment program. Some of the larger plants have obtained men through the civil service system or from municipal departments, namely the Public Works or Water Departments, but the smaller plants, whose operators constitute the greatest number in New England, have generally relied upon indirect methods. Some men have been on the construction crews that built the plant and asked to stay on as an operator. Others may have worked as students at the plant on a part-time basis and were asked to stay on full-time. Still others come to the job out of boredom of retirement or the desperation of unemployment.

Direct recruitment methods that have been used include advertising in local newspapers, drawing from civil service lists and mailing announcements of job opportunities directly to a number of treatment plants within the area. However, many plants have met with only limited success using these methods because of out-dated, rigid civil service systems and unrealistic salary scales. In addition, the public image of a sewage worker is a barrier in recruiting young, qualified operators.

Future Programs Needed

The Federal and State agencies involved with water pollution control as well as local officials and other interested groups can contribute greatly

in implementing a variety of recruitment programs in New England which will help to attract and keep the operators needed in the future.

First and most important, the image of the wastewater treatment worker in the eyes of the public must be improved. A plant operator must not be looked on as a "sewer worker". The public should think of a treatment plant as an expensive investment that will benefit the community as a whole if operated properly. Citizens must realize that, to gain this benefit, skilled technicians are required. To develop public awareness, plant officials might offer tours, and Federal and State officials might give lectures to schools, to local officials and to local groups. No matter how it is accomplished, the status of operators must be changed before young and competent people will consider a career in the wastewater treatment field.

There is a desperate need for literature describing the need for well trained personnel to operate today's modern treatment facilities and promoting the many challenging job opportunities in the field. Such literature could be used in established guidance programs at high schools, vocational schools and colleges. Rutgers Univeristy has prepared a booklet, "Careers in Water or Wastewater Operations", which presents the reasons more operators are needed, the opportunities for advancement, salary scales, educational and training opportunities and licensing regulations in New Jersey. The New England Interstate Water Pollution Control Commission is preparing a similar publication for New England. It will be used to describe the many opportunities, including the New England Regional Wastewater Institute, available to New England high school graduates and prospective employees.

To assist in improving the national image, the Federal government plans to undertake such steps as publishing a booklet for national distribution covering the whole subject of operator needs, opportunities and benefits. The government is also considering such ideas as expanding the public information and education program to include the ramifications of treatment plant operation -- acquainting the public and prospective employees with training needs, skills required, gains to be derived and losses to be incurred if plants are not properly operated.

An overall recruitment program could include some or all of the following methods: preparation and distribution of career opportunities literature; advertisements of job opportunities in local newspapers and magazines; presentations before local organizations, high school students and political groups; use of displays showing the handling of wastewater from collection to final treatment including literature describing the system and career opportunities; plant tours for local groups, officials and vocational and high school students; and establishment of a central referral system of job opportunities. All job opportunities in a State could be handled by each State water pollution control agency or employment agency so that anyone interested in a job could contact the agency and be supplied with a list of all jobs available. Occasionally, a list of the job openings could be published in regional newsletters, trade journals or magazines. It is important that, whatever methods of recruitment are used, the news of job openings and opportunities reach both working operators as well as potential operators.

Even with the best recruitment program, all efforts will be wasted without upgrading existing salaries, requiring mandatory certification and providing an adequate training program for wastewater treatment plant operators in New England.

APPENDIX

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TWO-YEAR

SANITARY ENGINEERING TECHNOLOGY CURRICULUM

(Associate of Applied Science Degree)

Fayetteville Technical Institute

Fayetteville, North Carolina

(1968)

COURSE OUTLINE

	Hours Per Week		Quarter Hours
	Class	Lab	Credit
FIRST QUARTER			
Grammar	3	0	3
Technical Mathematics	5	0	5
Physics: Properties of Matter	4	2	4
Technical Drafting	0	6*	2
Introduction to Sanitation	2	4	4
	13	12	18
SECOND QUARTER			
Composition	3	0	3
Technical Mathematics	5	0	5
Physics: Work, Energy, Power	3	2	4
Surveying	2	6*	4
Applied Biology	3	2	4
	16	10	20
THIRD QUARTER			
Report Writing	3	0	3
Technical Mathematics	5	0	5
Basic Microbiology	3	2	4
Basic Hydraulics: Principles of Flow	2	4	4
Technical Drafting	0	6	2
	13	12	18

* "Manipulative Laboratory" involves development of skills and job proficiency. Credit of one quarter hour for each three hours of laboratory.

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COURSE OUTLINE (Continued)

	Hours Per Week		Quarter Hours
	Class	Lab	Credit
FOURTH QUARTER			
Oral Communication	3	0	3
Sanitary Chemistry and Biology	2	4	4
Water Supply and Liquid Waste	3	2	4
Water Purification	4	3	5
Applied Electricity	2	4	4
	14	13	20
FIFTH QUARTER			
Applied Economics	3	0	3
Sanitary Chemistry and Biology	2	4	4
Liquid Waste Treatment	3	4	5
Control Systems	2	4	4
Drafting	0	5	2
	10	18	18
SIXTH QUARTER			
Applied Psychology	3	0	3
Sanitary Chemistry and Biology	2	4	4
Liquid Waste Treatment	3	4	5
Codes, Contracts, Specifications and Estimates	2	3	3
Field Surveying	0	6	2
	10	17	17

NINE-MONTH

WASTEWATER TREATMENT PLANT OPERATORS COURSE

New England Regional Wastewater Institute

South Portland, Maine

(1969)

COURSE OUTLINE

	Hours Per Week		
	Class	Lab	Credit Hours
FIRST SEMESTER			
Mathematics I	3	0	4
Water and Sewage Chemistry	3	2	4
General Biology	3	2	4
Fundamentals of Treatment Plant Operation I	2	3	3
Hydraulic Systems and Plant Operation	2	3	3
Valves, Meters and Filtering Operations	2	3	3
	15	13	21
SECOND SEMESTER			
Mathematics II	4	0	4
Blueprint Reading	3	0	3
Sanitary Microbiology	3	2	4
Fundamentals of Treatment Plant Operations II	3	0	3
Systems Operation and Industrial Control	3	0	3
Electrical Systems and Plant Safety	3	0	3
	19	2	20